ACCESSION #: 9402280032
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Catawba Nuclear Station, Unit 1 PAGE: 1 OF 9

DOCKET NUMBER: 05000413

TITLE: Turbine/Reactor Trip Due To Low Condenser Vacuum
EVENT DATE: 01/11/94 LER #: 94-001-00 REPORT DATE: 02/10/94

OTHER FACILITIES INVOLVED: N/A DOCKET NO: 05000

OPERATING MODE: 1 POWER LEVEL: 98

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION:
50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER:
NAME: Z. L. Taylor, Compliance Manager TELEPHONE: (803) 831-3812

COMPONENT FAILURE DESCRIPTION:
CAUSE: F SYSTEM: BN COMPONENT: PSP MANUFACTURER: N/A
REPORTABLE NPRDS: Y

SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

On January 11, 1994, at 2258 hours, a Unit 1 Reactor (Rx) trip occurred due to a main Turbine trip on low condenser vacuum. Unit 1 was in Mode 1, Power Operation, at 989. power, when a two inch "B" heater extraction line sheared off approximately six feet from entry into "A" condenser, resulting in a loss of vacuum to "A" condenser. The cause of the sheared extraction line was fatigue failure as a result of vibration over an extended period of time. Corrective actions included repairing the "B" heater extraction line and examination of other extraction lines on both units. Engineering is evaluating options to reduce the amount of vibration on the extraction lines. Following the Rx trip, a main feedwater (CF) isolation occurred as a result of the Rx trip with low Reactor Coolant average temperature (Tave). Both motor driven auxiliary feedwater system pumps autostarted as expected, when three out of four CF isolation valves closed within two minutes of turbine load decreasing below 40%. A P-12 (Lo-Lo Tave) actuation occurred when one bank of steam dump valves opened causing Tave to decrease below the P-12 setpoint of 553 degrees F. The cause of the P-12 actuation is that a procedure step

was not followed correctly. A contributing cause was controller windup due to a pressure transmitter that was reading higher than expected. Corrective actions include meeting with all Control Room Operators to discuss procedure adherence, controller windup, changes to Emergency Procedures that will provide more detail for transferring to the pressure control mode, and performing a calibration on the pressure transmitter.

END OF ABSTRACT

BACKGROUND

The main condenser [EIIS:COND] is designed to condense turbine [EIIS:TRB] exhaust steam for reuse in the steam cycle. The main condenser also serves as a collecting point for various steam cycle vents and drains to conserve condensate which is stored in the condenser hotwell. The condenser also serves as a heat sink for the Turbine Bypass System and is capable of handling 40 percent of rated main steam flow. Rejected heat is removed from the main condenser by the Condenser Circulating Water [EIIS:SG] (RC) system.

The circulating water side of the main condenser is a triple pass arrangement ("C" condenser to "B" condenser to "A" condenser) having two vertically divided water circuits. The main condenser will maintain back pressures of 2.4 ("C" condenser), 2.9 ("B" condenser), and 3.7 ("A" condenser) Inches Mercury (Hg) Absolute (Abs) in the three condenser shells when operating at rated turbine output with 89 degrees F inlet circulating water temperature and 95 percent clean tubes. Loss of condenser vacuum due to the accumulation of non-condensable gases is prevented by the steam air ejectors.

The condenser could become ineffective due to loss of cooling water or excessive air inleakage. These conditions would result in a high backpressure alarm at 5.0 In Hg. Abs., and at 7.5 In Hg. Abs., and the turbine would be automatically tripped. The excess reactor heat would then be removed as steam through the condenser dump valves [EIIS:V] until these valves are tripped closed on loss of condenser vacuum or loss of circulating water pumps [EIIS:P]. After closing the condenser dump valves, the excess heat would be relieved to atmosphere through the atmospheric dump valves, power operated relief valves and/or the American Society of Mechanical Engineering (ASME) Code safety valves.

The Condenser Steam Air Ejector [EIIS:SG] (ZJ) system consists of three condenser steam air ejectors (CSAE) per unit. Each CSAE has two sets of two stage jets with each set of jets capable of handling full design

capacity of 20 cubic feet per minute (cfm) of saturated air at 71.5 degrees F and 1.0 In Hg. Abs. when supplied with steam at 125 psia. Normally each CSAE draws the noncondensable gases and water vapor mixture from one of the three main condenser shells.

The Main Vacuum [EIIS:SH] (ZM) system consists of two main vacuum pumps connected to the condenser crossties on the Condenser Steam Air Ejector System to allow the main vacuum pumps to evacuate the main condenser, the main turbine casing and the upper surge tanks during startup. Each main vacuum pump is designed to remove 3050 cfm of air with suction conditions of 20 In. Hg. vacuum and 80 degrees F. These pumps are only used during startup since normal operation requires the use of the CSAEs only.

The Main Feedwater [EIIS:SJ] (CF) system consists of two steam driven feedwater pumps, two stages of high pressure feedwater heaters (A and B), piping [EIIS:PSP], valves, and instrumentation. Normally, both feedwater pumps will be operating with each pump handling half the feedwater flow. Downstream of the feedwater pumps, the feedwater passes through two stages of high pressure heaters to a final header where the temperature is equalized. The feedwater is then admitted to the steam generators [EIIS:HX] (S/G) through four steam generator feedwater lines, each of which contains a control valve and a flow nozzle.

The purpose of the feedwater isolation signal is to initiate isolation of each steam generator and rapidly terminate feedwater flow and steam blowdown inside containment [EIIS:NH] following a main steam or feedwater line break in containment, to prevent loss of steam generator water inventory due to a pipe rupture outside containment, and to prevent overfilling the steam generators if for some reason the normal means of controlling steam generator level malfunctions. Feedwater isolation is activated by any one of the following signals: safety injection, reactor trip plus low average reactor coolant temperature (T-ave less than 564 degrees F) , or Hi-Hi Steam Generator level. A feedwater isolation signal closes the Feedwater Isolation Valves, Feedwater Purge Valves, Feedwater Control Valves, Feedwater Control Bypass Valves, Feedwater Preheater Bypass Valves, and Feedwater Bypass Tempering Flow Valves.

The Auxiliary Feedwater [EIIS:BA] (CA) system provides an assured source of emergency feedwater to the S/Gs during plant conditions when the CF system is not available. The CA system for each unit includes two motor driven pumps (MDP A and B), powered by separate and redundant safety related power supplies, and a steam powered turbine driven pump (TDP).

The CA MDP autostart signal is initiated from any one of the following

conditions:

1) safety injection
2) loss of emergency bus power
3) low-low level in any S/G
4) both main feedwater pumps tripped
5) start signal from the Anticipated Transient Without Scram (ATWS) Mitigation System Actuation Circuitry (AMSAC)

During a CA autostart, the CA MDPs start, the CA discharge valves [EIIS:V] for each train fully open, and the S/G Blowdown [EIIS:WI] (BB) and Nuclear Sampling [EIIS:KN] (NM) systems isolate from the S/Gs.

Anticipated Transient Without Scram Mitigation System Actuation Circuitry (AMSAC) is a nonsafety related control logic in addition to and separate from the Reactor Protection System [EIIS:JC] (RPS), used to ensure reactor cooling via the CA system in the event of an ATWS. An ATWS event is any condition causing an interruption of main feedwater to the S/Gs without the appropriate reactor scram. The AMSAC system is comprised of the necessary control components to detect an ATWS event and then provide the necessary actions to mitigate the event. AMSAC actuation occurs when either of two conditions exists. These conditions are both main feedwater pumps tripped or blockage of CF flow to the S/Gs due to inadvertent valve closure (s) . Either event constitutes an interruption of normal feedwater flow to the S/GS. On Unit 1, the AMSAC circuit remains armed two minutes after turbine load decreases below 40%. If within the two minute interval, three out of four CF isolation valves close, the AMSAC circuit is activated. On actuation, the AMSAC circuitry will perform the following:

1) trip the main turbine
2) start both CA MDPs
3) isolate the BB and NM systems from the S/Gs

The purpose of the Steam Dump [EIIS:JI] (IDE) system is to: 1) enable the Reactor to follow Main Turbine load reductions of greater than 10% and 30% step changes; 2) allow unit load reduction from 100% to plant auxiliary loads without a Reactor trip; 3) allow a turbine trip and Reactor trip from 100% without lifting the Main Steam [EIIS:SB] (SM) system Safety Valves. The system accomplishes its purpose by the use of five banks of dump valves divided into condenser dumps and atmospheric dumps. Condenser dump valves are divided into three banks with three valves per bank. Atmospheric dump valves are divided into two banks with four and five valves per bank, respectively. The total capacity of the Steam Dump System is 71.5% of the total unit capacity.

The condenser and atmospheric dump valves are controlled by one of three controllers [EIIS:KC] (steam pressure, load rejection, plant trip). The steam pressure controller actuates to control steam pressure at or near a set reference signal. The reference signal to the dump valves is filtered through a pneumatic circuit which contains block valves and arming valves. This "block" circuit prevents cooldown below 553 degrees F to ensure Tave remains above the minimum temperature for criticality.

The P-12, Lo Lo Tave Interlock, is part of the Engineered Safety Features Actuation System [EIIS:JE]. The purpose of the interlock is to block steam dump valve actuation to prevent excessive cooldown below the minimum temperature for criticality. Its setpoint is 553 degrees F on any two out of four NC system loops. If the logic is satisfied, Steam Dump Valves are failed closed until NC system temperature is above 553 degrees F.

EVENT DESCRIPTION

On January 11, 1994, at 2100 hours, Unit 1 was in Mode 1, at 98% power, with Reactor Coolant System Average Temperature (Tave) at 589.4 degrees F. "A" Condenser vacuum was at approximately 26.5 inches mercury (Hg).

At 2130 hours, Control Room Operators (CROs) noticed condenser vacuum began decreasing. CROs began investing the source of the vacuum leak. Unit Supervisor referenced AP/1/A/5500/23, Loss of Condenser Vacuum.

At 2140 hours, Condenser "A" vacuum had stabilized at approximately 25 inches Hg with an associated loss of megawatt output. "A" Condensate Steam Air Ejector (CSAE) was found running roughly and was suspected to be waterlogged. An idle CSAE was placed in service on "A" condenser with little effect. Indications of 1F1 and 1G1 heater shell pressures led operators to believe there was a problem with "A" condenser. Feedwater heaters 1F1 and 1G1 are inside "A" condenser. Operations continued to investigate the source of the vacuum leak.

At 2256 hours, "A" condenser vacuum began a rapid decrease.

At 2258:50 hours, the Main Turbine tripped due to Low Condenser vacuum (21.8 inches Hg). A two inch "B" extraction line sheared off approximately six feet from entry into "A" condenser, resulting in loss of vacuum to "A" condenser. The Main Turbine trip caused a Reactor Trip because Reactor power was above the P-9 setpoint. The P-9 interlock initiates a Reactor trip on a Main Turbine trip when Reactor power is greater than 69% power. The CROs immediately entered EP/1/A/5000/01, Reactor Trip or Safety

Injection, to verify the plant responded properly and to assess plant conditions. The CROs then entered procedure EP/1/A/5000/01A, Reactor Trip response, per EP/1/A/5000/01.

At 2259:08 hours, Main Feedwater isolation occurred as a result of Tave decreasing below 564 degrees F after the Reactor trip. Feedwater isolation is activated by a Reactor trip and low Tave (less than 564 degrees F).

At 2259:16 hours, CA pumps 1A and 1B autostarted as expected, due to an AMSAC signal being generated. The AMSAC circuit was activated when the CF isolation valves (3 out of 4) went closed within 2 minutes of turbine load decreasing below 40%.

At 2304:38 hours, a CRO placed steam dump controller in the pressure mode. As the controller was switched to the pressure mode, one bank of steam dumps opened causing Tave to decrease. The CRO took the controller to manual and closed the steam dump valves. Tave had decreased to 553 degrees F causing P-12 (Lo-Lo Tave) interlock to actuate. P-12 actuation blocks the

steam dump valve actuation to prevent excessive cooldown below the minimum temperature for criticality.

At 2312 hours, Tave had decreased to 546 degrees F. (546 degrees F was the lowest temperature reached during the transient).

At 2328 hours, Tave had returned to no load Tave (557 degrees F).

On January 12, 1994, at 0014 hours, C-9 interlock was lost due to vacuum in the main condenser being less than 20 inches Hg. C-9 Interlock allows arming of the condenser dump valves if condenser pressure is greater than 20 inches of Hg and the RC system pump breaker is closed. Steam Generator (S/G) Power Operated Relief Valves (PORVs) were used to maintain Reactor Coolant (NC) system temperature due to loss of C-9 interlock.

At 0045 hours, Maintenance placed a cap over the damaged two inch "B" heater extraction line. "B" main vacuum pump was started and condenser pressure began to increase to 25 inches Hg. C-9 interlock was restored and the S/G PORVs were closed. Steam dumps began to operate to maintain NC temperature.

At 0100 hours, placed "A" CF pump in service to feed all S/Gs and Digital Feedwater Control System was placed in auto. Secured 1A and 1B CA motor driven pumps.

CONCLUSION

Reactor Trip

The Turbine/Reactor Trip was due to low condenser vacuum as a result of a sheared off "B" heater extraction line. The sheared pipe was due to fatigue failure as a result of vibration over an extended period of time. Corrective actions included repairing the "B" heater extraction line, performing Liquid Penetrant examination on areas of the "B" extraction lines that were identified as stress points and examining Unit 2 "B" extraction lines. Engineering is evaluating the options to reduce the amount of vibration on the heater extraction lines for both units. The areas that were examined by Liquid Penetrant testing were acceptable. The examination of the Unit 2 "B" heater extraction line also revealed a problem with vibration. The two inch "B" heater extraction line failure is NPRDS reportable.

During this event the CROs entered the correct emergency response and abnormal procedures (EPs and APs) and performed the required steps to maintain the plant in a safe shutdown condition. All safety systems responded as designed to shutdown the Reactor and maintain it in a safe shutdown condition.

A review of the Operating Experience Program database for the 24 months prior to this event did not identify any Reactor trips that were attributed to a turbine trip as a result of low condenser vacuum. Therefore, this incident is considered not to be recurring.

P-12 Actuation

The cause of the P-12 actuation is that a procedure step was not followed correctly. When the operators got to the step to place the steam dumps in the pressure mode, they were to verify that no demand was indicated on the steam dump controllers prior to transferring to the pressure mode. At the time the steam dump controller was indicating 60% demand. The operators verified that the % steam dump demand meter on the control board was indicating zero and that all four steam generator pressures were below steam dump controller setpoint (1090). Based on the parameters checked the operators did not feel like there was a problem going to the pressure mode. Once the steam dump controller was placed in the pressure mode, the steam dump valves opened due to 60% demand of the steam dump controller. Operators took the controller to manual and closed the dump valves. Tave had decreased below the P-12 setpoint of 553 degrees F, thus causing the

P-12 actuation. The reason the steam dump controller was indicating 60% demand was due to controller windup. The controller windup was a result of pressure transmitter 1SMPT5200 indicating that main steam header pressure was above the steam dump controller setpoint, even though it actually was not. Pressure transmitter 1SMPT5200 appears to be reading 20 pounds higher than main steam header pressure.

Corrective actions include meeting with all Control Room Operators to discuss procedure adherence, controller windup, and future changes to Emergency Procedures that will provide more detail for transferring to the pressure control mode. Also, a calibration of pressure transmitter 1SMPT5200 will be conducted at the earliest possible opportunity.

A review of the Operating Experience Program database for the past 24 months prior to this event identified three LERs reporting engineered safety feature actuations involving the lo-lo Tave interlock (P-12). Two of the reportable events were caused by inadvertent opening of steam dumps linked to process control cards for steam dumps. The third event was due to an operator not adequately evaluating that additional steam loads would significantly reduce NC temperature while in Mode 3, Hot Standby. Since the root cause for this event is different than these past events, this event is not considered recurring.

CORRECTIVE ACTIONS

Turbine/Reactor Trip

Immediate

1) CROs entered procedure EP/1/A/5000/01, Reactor Trip or Safety Injection, to verify the plant responded properly and to assess plant conditions.

2) CROs entered procedure EP/1/A/5000/01A, Reactor Trip Response, per EP/1/A/5000/01.

Subsequent

1) CROs used S/G PORVs to control NC cooldown due to loss of C-9 permissive.

2) Maintenance installed a cap over the two inch "B" heater extraction line so that vacuum could be maintained in the condenser. The work was performed under work Order 94002993-01.

3) Liquid Penetrant examination was performed on areas of the extraction line that were identified as stress points. This was performed to verify that no surface cracks existed due to vibration. The work was performed under Work Order 94003266-01.

4) Inspected the Unit 2 "B" heater extraction line to evaluate whether the line had a vibration problem.

Planned

1) Engineering is evaluating options to reduce the amount of vibration on Unit 1 and Unit 2 heater extraction lines.

2) Liquid Penetrant examination will be performed on stress points identified on other heater extraction lines.

P-12 Actuation

Immediate

1) CROs took the steam dump controller to manual and closed the steam dump valves.

Planned

1) A meeting will be held with all Control Room Operators to discuss procedure adherence, controller windup, and future changes to Emergency Procedures that will provide more detail for transferring condenser dumps to the pressure mode.

2) Calibrate pressure transmitter 1SMPT5200 per Work Order 94007877-01.

SAFETY ANALYSIS

This event was initiated due to low vacuum in "A" condenser which resulted in a main turbine/reactor trip. The event is bounded by the Safety Analysis documented in FSAR Section 15.2.3, Turbine Trip.

Unit 1 was in Mode 1 at 98% power at the time of this incident. Unit 1 reactor trip occurred due to turbine trip above 69% reactor power (P-9). Following the Rx trip, Tave decreased below 564 degrees F, resulting in a main feedwater isolation. CA autostart occurred because three out of four

CF isolation valves closed within two minutes of turbine load decreasing below 40%. As the plant stabilized, CRO placed the steam dump controller in the pressure mode and one bank of the steam dump valves opened. The CRO took the steam dump controller to manual and closed the steam dump valves. P-12 actuation occurred as a result of Tave decreasing below 553 degrees F. The P-12 interlock functioned as designed when Tave reached 553 degrees F. The lowest Tave reached during the cooldown was 546 degrees F. Later in the event the S/G PORVs were used for approximately 30 minutes because the C-9 permissive for steam dump valves to actuate was blocked due to low condenser vacuum. The cooldown portion of the NC system experienced during this event is bounded by the Safety Analysis documented in the FSAR Section 15.1.5, Steam System Piping Failure.

After a review of this event all systems responded as designed to shutdown the reactor and maintain it in a safe condition. There were no unusual releases of radioactive material.

The health and safety of the public were not affected by this event.

Duke Power Company (803) 831-3000
Catawba Nuclear Station
4800 Concord Rd.
York, S.C. 29745

DUKEPOWER

February 10, 1994

Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Catawba Nuclear Station
Docket No. 50-413
LER 413/94-001

Gentlemen:

Attached is Licensee Event Report 413/94-001, concerning TURBINE/REACTOR TRIP DUE TO LOW CONDENSER VACUUM.

This event was considered to be of no significance with respect to the health and safety of the public.

Very truly yours,

D. L. Rehn

xc: Mr. S. D. Ebneter Marsh & McLennan Nuclear
Regional Administrator, Region II 1166 Avenue of the Americas
U. S. Nuclear Regulatory Commission New York, NY 10036-2774
101 Marietta Street, NW, Suite 2900
Atlanta, GA 30323

Mr. R. E. Martin INPO Records Center
U. S. Nuclear Regulatory Commission Suite 1500
Office of Nuclear Reactor Regulation 1100 Circle 75 Parkway
Washington, D.C. 20555 Atlanta, GA 30339

Mr. R. J. Freudenberger
NRC Resident Inspector
Catawba Nuclear Station

bxc: B. L. Walsh - EC11C
C. A. Paton - PB02L
A. V. Carr - PB05E
B. J. Horsley - EC03U
S. G. Benesole - ON03RC
T. E. Mooney - EC05N
G. H. Savage - CH03C
R. O. Sharpe - MG01RC
NSRB Staff - EC12A
D. L. Rehn - CN01VP
W. R. McCollum - CN01SM
O. J. Helton - CN03WC
NC MPA-1
NCEMC
PMPA
SREC

J. W. Glenn - CN05SR (with Enclosures)
R. F. Cole - EC05N (with Enclosures)
SRG - CN05SR (with Enclosures)
Master File - CN02DC CN-815.04 (with Enclosures)

*** END OF DOCUMENT ***